PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : E21B 21/00, 21/08	A1	(11) International Publication Number: **WO 99/34090** (43) International Publication Date: 8 July 1999 (08.07.99)

(21) International Application Number: PCT/NL97/00725

(22) International Filing Date: 24 December 1997 (24.12.97)

(71) Applicant *(for all designated States except US)*: WELL ENGINEERING PARTNERS B.V. [NL/NL]; Tynaarlosestraat 68, NL-9481 AE Vries (NL).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: VAN WECHEM, Gustaaf, Louis [NL/NL]; Kamille 7, NL-2811 RD Reeuwijk (NL). BAKKER, Thomas, Walburgis [NL/NL]; Tynaarlosestraat 68, NL-9481 AE Vries (NL).

(74) Agent: SMULDERS, Th., A., H., J.; Vereenigde Octrooibureaux, Nieuwe Parklaan 97, NL-2587 BN The Hague (NL).

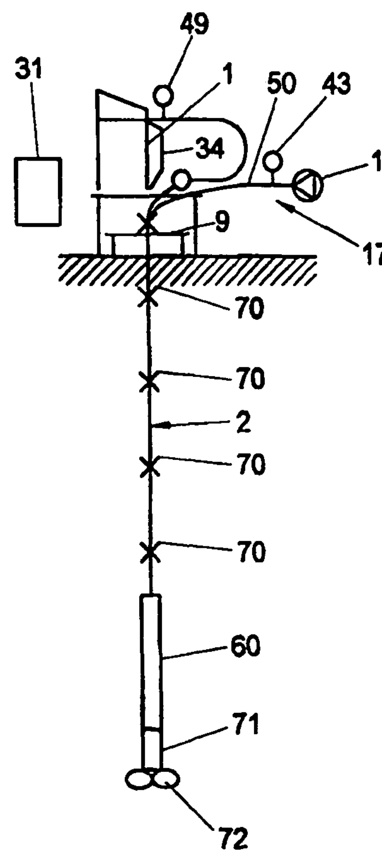
(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, GM, GW, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).

Published
With international search report.

(54) Title: OFF-LINE MUD CIRCULATION DURING LITHOSPHERE DRILLING

(57) Abstract

During the drilling of a bore hole in the litosphere, mud is fed to a drill string (2) via a mud circulation structure and canalized through the drill string (2) to a distal end of the drill string (2). Each time the drill string (2) has progressed into the litosphere over a predetermined distance, the drill string (2) is disconnected from the mud circulation structure so that the feeding of mud to the drill string (2) is interrupted. A buffer quantity of mud is stored in the drill string (2) during the feeding of mud to the drill string and at least a portion of the buffer quantity of mud is fed in the direction of the distal end of the drill string (2) during the interruption of the feeding of mud to the drill string (2). Thus, the interruption of the supply of mud at the distal end of the drill string can be reduced or eliminated.



FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	**ES**	Spain	**LS**	Lesotho	**SI**	Slovenia
AM	Armenia	**FI**	Finland	**LT**	Lithuania	**SK**	Slovakia
AT	Austria	**FR**	France	**LU**	Luxembourg	**SN**	Senegal
AU	Australia	**GA**	Gabon	**LV**	Latvia	**SZ**	Swaziland
AZ	Azerbaijan	**GB**	United Kingdom	**MC**	Monaco	**TD**	Chad
BA	Bosnia and Herzegovina	**GE**	Georgia	**MD**	Republic of Moldova	**TG**	Togo
BB	Barbados	**GH**	Ghana	**MG**	Madagascar	**TJ**	Tajikistan
BE	Belgium	**GN**	Guinea	**MK**	The former Yugoslav Republic of Macedonia	**TM**	Turkmenistan
BF	Burkina Faso	**GR**	Greece			**TR**	Turkey
BG	Bulgaria	**HU**	Hungary	**ML**	Mali	**TT**	Trinidad and Tobago
BJ	Benin	**IE**	Ireland	**MN**	Mongolia	**UA**	Ukraine
BR	Brazil	**IL**	Israel	**MR**	Mauritania	**UG**	Uganda
BY	Belarus	**IS**	Iceland	**MW**	Malawi	**US**	United States of America
CA	Canada	**IT**	Italy	**MX**	Mexico	**UZ**	Uzbekistan
CF	Central African Republic	**JP**	Japan	**NE**	Niger	**VN**	Viet Nam
CG	Congo	**KE**	Kenya	**NL**	Netherlands	**YU**	Yugoslavia
CH	Switzerland	**KG**	Kyrgyzstan	**NO**	Norway	**ZW**	Zimbabwe
CI	Côte d'Ivoire	**KP**	Democratic People's Republic of Korea	**NZ**	New Zealand		
CM	Cameroon			**PL**	Poland		
CN	China	**KR**	Republic of Korea	**PT**	Portugal		
CU	Cuba	**KZ**	Kazakstan	**RO**	Romania		
CZ	Czech Republic	**LC**	Saint Lucia	**RU**	Russian Federation		
DE	Germany	**LI**	Liechtenstein	**SD**	Sudan		
DK	Denmark	**LK**	Sri Lanka	**SE**	Sweden		
EE	Estonia	**LR**	Liberia	**SG**	Singapore		

TITLE: Off-line mud circulation during lithosphere drilling

TECHNICAL FIELD

The invention relates to the drilling of a bore hole in the lithosphere involving circulation of mud through the drill string, for instance in the course drilling or lining oil or gas wells, and to equipment therefor.

BACKGROUND ART

Drilling for oil or gas typically involves the introduction of a large number of pipe sections or stands such as drill pipe sections and casing pipe sections into the well, in particular if it is desired to rotate the drill string during drilling. The sections are each time connected to a drill string composed of sections projecting into the well after having been brought into line with the drill string. Each section may be formed by a single joint or by a plurality of joints which have been connected to each other before being connected to the drill string.

During drilling, mud is being fed to the drill string for instance to drive a mud motor connected to a drill bit at the extreme end of the pipe string and/or, as a lubricant, to facilitate introduction of the drill string into the bore hole. It is also known to circulate mud during tripping (introduction or re-introduction of a drill string into a previously bored hole and extraction of a drill string from a bore hole).

Couplings between the pipe string and pipe sections to be added to the drill string are typically made by screwing the pipe sections onto the pipe string each time the pipe string has been introduced into the bore hole over a predetermined distance corresponding to the length of a previously added drill pipe section.

The efficiency and effectivity of such operations is substantially impaired by the interruptions of the mud flow

and, during drilling, of the drilling process, each time a drill pipe section is to be connected to the drill string. More specifically, stopping the mud flow has various adverse effects such as gelation of mud in the bore hole and an increase of the risk of the pipe string getting stuck in the bore hole. Furthermore, it takes a substantial time after re-starting before the drilling process has again reached its normal operating equilibrium.

SUMMARY OF THE INVENTION

It is an object of the present invention to enable to at least reduce the interruption of the drilling process each time a pipe string section is connected to the pipe string.

According to the present invention, this object is achieved by providing a method for drilling a bore hole in the lithosphere, including:

- the feeding of mud to a drill string via a mud circulation structure;
- canalizing mud through the drill string to a distal end of the drill string; and
- each time the drill string has progressed into the lithosphere over a predetermined distance, disconnecting the drill string from the mud circulation structure so that the feeding of mud to the drill string is interrupted, connecting a drill pipe section to the mud circulation structure and connecting the drill pipe section to the drill string, wherein a buffer quantity of mud is stored in the drill string during the feeding of mud to the drill string and wherein at least a portion of the buffer quantity of mud is fed in the direction of the distal end of the drill string during the interruption of the feeding of mud to the drill string.

The invention also provides a storage device for storing mud in a drill string during lithosphere drilling, the device including: a first connection structure for connection to a drill pipe section or to an identical device,

the first connection structure including a first passage to allow the passage of mud; a second connection structure opposite the first connection structure, for connection to a drill pipe section, to a mud motor or to a first connection structure of an identical device, the second connection structure including a second passage to allow the passage of mud; a mud flow channel interconnecting the first and second passages; a buffer storage space communicating with the mud flow channel for storing a buffer quantity of mud; and an expulsion structure for expelling at least a portion of a buffer quantity of mud from the storage space.

By directing mud buffered in the drill string towards the distal end of the drill string while the feeding of mud to the drill string is interrupted, the supply of mud to the distal end of the drill string can be maintained during at least a portion of the time during which the feeding of mud to the drill string is interrupted. This in turn at least allows to regain a normal operating equilibrium earlier after the moment the feeding of mud to the drill string has been resumed. According to a particularly advantageous mode of carrying out the invention, drilling is continued during at least a portion of, and preferably the whole of, a time interval during which the feeding of mud to the drill string is interrupted. Also during tripping it is advantageous if the supply of mud to the distal end of the drill string is interrupted as briefly as possible and preferably continuous. This applies to inserting a drill string into a bore hole as well as to removing a drill string from a bore hole.

One particularly advantageous embodiment of the invention is formed by a drill string including at least one mud storage device as described above and including at least a one-way valve upstream of the buffer storage space, to ensure that mud from the buffer storage space is directed to the distal end of the drill string and does not flow back.

Another particularly advantageous embodiment of the invention is formed by a lithosphere drilling assembly including a drill string including a mud storage device as

described above and a mud circulation structure for circulating mud to a pipe string projecting into a bore hole in the lithosphere, the mud circulation structure including: a mud pump, at least two mud heads, at least one conduit for directing mud from the mud pump to and through each of the mud heads, and means for shutting off the mud flow conduit for alternately directing the mud flow through each one of the mud heads.

By connecting another mud head of the mud circulation structure to a pipe section to be connected, the time during which the mud circulation structure is disconnected from the pipe string can be reduced substantially, so that a reduced amount of mud is required to continue the supply of mud to the distal end of the drill string during the time interval when the feeding of mud to the drill string is interrupted. This is particularly advantageous if drilling is to be continued each time a drill pipe section is connected.

Yet another particularly advantageous embodiment of the invention is formed by a drilling rig for lithosphere drilling including a lithosphere drilling assembly as described above, a structure for moving a pipe string along a pipe string axis and a mud head guide structure for guiding the mud heads along a circulating path including a section co-axial with the pipe string axis. As a mud head is guided along the section of the circulating path which is co-axial with the pipe string axis, a top end of a newly connected pipe section can be guided until it is engaged by a pipe section engaging structure. It is noted that the mud heads can in principle also be guided for movement to and fro between ends of separate paths.

A further particularly advantageous embodiment of the invention is formed by a drilling rig for lithosphere drilling including a lithosphere drilling assembly as described above and a pipe string drive unit for driving rotation of a pipe string axially projecting into a bore hole in the lithosphere, which pipe string drive unit includes: a pipe string engagement structure for circumferentially

engaging the pipe string; and a pipe string drive including a drive motor operatively coupled to the pipe string engagement structure and to a rotationally fixed support structure for driving rotation of the pipe string engagement structure. The pipe string drive unit has a continuous passage for receiving a portion of the pipe string. Thus, a pipe string engaged by the pipe string drive unit is accessible at its proximal end for co-operation with a mud head of the mud circulation structure.

Further objects, modes, embodiments and details of the invention appear from the dependent claims and the description in which reference is made to the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Figs. 1-6 are schematic side views representing successive stages of the method according to the invention;

Fig. 7 is a cross-sectional side view of a mud buffer storage;

Fig. 8 is a cross-sectional side view of another mud buffer storage;

Fig. 9 is a schematical side view of a drilling rig with a drill string projecting into the earth; and

Fig. 10 is a cross-sectional side view of a storage device for storing mud in a drill string.

MODES FOR CARRYING OUT THE INVENTION

In Figs. 1-6, a presently most preferred example of a rotary drilling rig for drilling into the lithosphere is schematically depicted in successive stages of an operation of adding a drill pipe section 1 - in this case a single joint drill pipe section - to a drill string 2. Further drill pipe sections 1' and 1'' are stored in a drill pipe section dispenser 3 aside the drill string 2.

The drilling rig has a well head 4. Above the well head 4, a rotatable clamp 9 is mounted to a vertically movable,

lower drilling table (not shown). In the situation shown in Fig. 1, the drill string 2 is releasably suspended from the clamp 9. The clamp 9 is connected to a drive 10 for driving rotation of the drill string 2 with a torque of up to about 15,000 - 25,000 Nm. The design of the clamping section of the clamp 9 can in principle be similar to that of conventional spiders for stationary mounting on a rig floor.

Above the clamp 9 and co-axial therewith, a pipe coupling unit 11 is mounted to an upper drilling table (not shown) which is vertically movable as well. The pipe coupling unit 11 has a drill pipe section clasping structure 12 for engaging the drill pipe section 1. The pipe coupling unit 11 is further provided with a drill string clasping structure 13 for engaging the drill string 2, which structure 13 is located coaxial with the drill pipe section clasping structure 12 and in a position axially different from the position of the drill pipe section clasping structure 12. Thus, the pipe coupling unit 11 also forms a drill string drive unit. For the sake of conciseness, this unit will however be referred to as pipe coupling unit 11. The designs of the drill pipe section clasping structure 12 and of the drill string clasping structure 13 can for instance be essentially identical to that of a known spider or elevator with active power-assisted clamping to ensure sufficient traction also if the drill string is still short and therefore of light weight. Preferably, both clasping structures are capable of transferring a make-up torque of about 50,000 to 120,000 Nm to the respective engaged pipe portions. The drill pipe section clasping structure 12 should preferably be capable of retaining drill pipe sections against axial loads of at least 2,500 to 3,000 kg. The drill string clasping structure 13 should be able to carry the whole weight of a pipe string suspended in a bore hole, which can be up to about 500,000 kg for a casing string when the string is at its full length.

For rotating the drill string clasping structure 13 and for rotating the drill pipe section clasping structure 12

relative to the drill string clasping structure 13, a drill string drive and a drill pipe section drive including drive motors are provided. For examples of these drives, reference is made to applicant's co-pending PCT application entitled "Making and breaking of couplings between drill pipe sections in a drilling rig", which has the same filing date as the present application.

For circulating mud to a drill string 2 projecting into a bore-hole in the lithosphere, a mud circulating structure is provided, including: a mud pump 14, two mud heads 15, 16, a conduit 17 for directing mud from the mud pump 14 to each of the mud heads 15, 16; and valves 19 (see Fig. 8) for shutting off the mud flow conduit 17 for alternately preventing mud flow through each of the mud heads 15, 16. The valves 19 also form blow-out preventers.

As appears from Fig. 8, the mud head includes a head portion 20 in which a connecting portion 21 is suspended rotatably by a sealed bearing 22. In the head portion, a passage leading to a buffer 49 meets the conduit 17.

In Fig. 9 the drilling rig according to Figs. 1-6 including a subsoil portion of the drill string 2 is shown. The drill string 2 is provided with a storage device 60 for storing mud in the drill string 2 during lithosphere drilling. This device is shown in more detail in Fig. 10.

The storage device 60 includes a first connection structure 61 for connection to a drill pipe section or to an identical device. This connection structure is provided with an entry passage 62 to allow the entry of mud into the device 60. Opposite the first connection structure 61 a second connection structure 63 for connection to a drill pipe section, to a mud motor or to a first connection structure 61 of an identical device, is provided. The second connection structure 63 is provided with a second passage 64 for the discharge of mud from the device. Between the first and second passages 62, 64 a mud flow channel 65 interconnecting the passages 62, 64 is provided. The device is further provided with a buffer storage space 66 for storing a buffer

quantity of mud and an expulsion structure 67 for expelling at least a portion of a buffer quantity of mud from the storage space 66. The connection structures 61, 63 are connected by a housing 68 which also forms a boundary of the mud storage space 66. The mud storage space 66 communicates with the channel 65 via a passage 69. A plurality of one-way valves 70 are provided in the drill string 2 to prevent mud from flowing back to the proximal end of the drill string 2.

The expulsion structure 67 is provided in the form of a passive resilient structure for increasing the volume of the buffer storage space in response to a pressure rise in the buffer storage space 66 and for reducing the volume of the buffer storage space 66 in response to a pressure drop in the buffer storage space 66. This allows to store a buffer quantity of mud in the buffer storage space 66 in response to loading the resilient structure and to direct mud to the distal end of the drill string in response to relief of the resilient structure. Thus, the need of providing a special energy supply to drive the mud buffer storage device 61 is avoided.

By adapting the cross-section of the passage 69, the velocity at which mud is urged out of the chamber 66 in response to a given pressure drop in the channel 65 can be adjusted to the duration of the interruption of the feeding of mud to the drill string 2.

More in particular, the expulsion structure 67 is formed by a resilient structure which is compressible by increasing the pressure in the buffer storage space 66 and expandable by reducing the pressure in the buffer storage space 66. In operation, the buffer quantity of mud is stored in the buffer storage space 66 while compressing the expulsion structure 67. The directing of at least a portion of the stored buffer quantity of mud to the distal end of the drill string 2 is accomplished by expansion of the expulsion structure 67. This allows the housing 68 to be of a substantially rigid structure, which is advantageous in view of the heavy loads to which the housing is subjected.

The expulsion structure includes a chamber 73 containing a propellant and partially bounded from the mud buffer storage chamber 66 by a displaceable boundary 74. Since the boundary 74 is supported by a propellant such as nitrogen, the pressure on opposite sides of the boundary is substantially equal and keeps loads on seals between the propellant and the mud relatively low. A particularly rugged construction is obtained because the boundary is formed by a piston 74 which is movable to and fro within the device 60. The piston has seals 76 which are slidable along wall surfaces of the housing 68. The range of travel of the piston 74 is limited by end stops 80, 81. It is also possible to provide a membrane, as in the buffer storages 43, 49, 50, to separate the propellant from the mud.

To adapt the pressure/displacement behaviour of the boundary 74, the amount of propellant in the chamber 73 can be changed by adding or removing propellant via a valve 79.

A particularly slender construction allowing a high buffer capacity is obtained because the buffer storage space 66 is contained in a ring-shaped chamber 73 co-axial with the channel 65 along which the mud is to be passed to the mud motor 71. A modular system of buffers of different capacities can be provided in a simple manner by providing housings 68 with cylindrical inner and outer wall portions 77, 78 of different lengths. All other parts can be equal for devices 60 of different capacity.

The piston 74 being ring-shaped provides the advantage that tilting of the piston 74 is effectively counteracted by the inner cylindrical wall portion 77 projecting to the central passage of the piston 74. This in turn allows the provision of a flat, light and little space-occupying piston.

In operation, adding a drill pipe section 1 to a drill string 2 starts with the picking up of a drill pipe section 1 from the dispenser 3. For this purpose and for transferring drill pipe sections 1 from the dispenser 3 to the proximal end of the drill string 2 projecting into a bore hole in the lithosphere and vice versa, a pipe handler 34 is provided.

This pipe handler 34 includes a drill pipe section engagement structure 35 for releasably engaging drill pipe sections to be transferred. To guide and drive the drill pipe section engagement structure 35 between a position adjacent the dispenser 3 and a position and orientation in line with the drill string 2, a lift unit (not shown) is provided which is guided by vertical guide rails. For further details regarding the lift unit, reference is again made to applicant's co-pending PCT application entitled "Making and breaking of couplings between drill pipe sections in a drilling rig".

The drill pipe section handler 34 further includes a drive, schematically depicted by square 40, connected to the drill pipe section engagement structure 35 for driving rotation of that drill pipe section engagement structure 35. According to the present example, the drill pipe section engagement structure 35 and the drive 40 are of essentially the same design as that of a conventional Iron Roughneck. However, the skilled person will appreciate that many other possibilities of driving rotation of the drill pipe section engagement structure 35 of the drill pipe section handler 34 are possible.

The drill pipe section handler 34 further includes a stabilising arm 41 projecting under the drill pipe section engagement structure 35 and having a gripper 42 adjacent its lower end. This arm 41 prevents substantial pendular motion of a drill pipe section 1 retained in the drill pipe section engagement structure 35.

While the drill pipe section is being transferred from the dispenser 3 to the proximal (in this case upper) end of the drill string 2, rotation and axial displacement of the drill string 2 is continued and mud is fed through the conduit 17 and via the mud head 16 connected to the drill string 2. This is represented by the blackened portion of the conduit 17. While mud is being fed to the drill string 2, a portion of the mud fed to the drill string is stored in the buffer storage space 66 of the device 60 for storing mud

until the mud pressure at the entry 69 of the storage space 66 is equal to the pressure in the mud storage space 66.

In the situation shown in Fig. 1, just after a previous drill pipe section has been connected, the drill string 2 is driven by the rotating spider clamp 9 as in the situation shown in Fig. 6. At latest just before the rotating spider clamp 9 has reached the lower end of its range of travel, the driving of the drill string 2 is taken over by the pipe coupling unit 11, by first engaging the drill string clasping structure 13 to the drill string 2 and by releasing the rotating spider clamp 9 from the drill string 2.

The mud heads 15, 16 are guided by a mud head guide track 36 for guiding the mud heads 15, 16 along a circulating path including a section 37 co-axial with the drill string axis. The mud head 16 is guided by the vertical portion 37 as the drill string 2 progresses into the earth.

Just before the clamp 9 has reached its lowest position, the drill string clasping structure 13 is brought into engagement with the proximal end of the drill string 2 and takes over the function of driving the drill string. Subsequently, the lower drill table 5 is returned to its upper take-over position. This position of the clamp 9 is shown in Fig. 2.

Fig. 2 further shows the operation of connecting the mud head 15 to the drill pipe section 1 to be connected to the string 2. To make the connection between the drill pipe section 1 and the mud head 15, the drill pipe section 1 is spun relative to the mud head 15 and thereby screwed to the mud head 15. During a final portion of the rotation of the drill pipe section 1, the drill pipe section is driven with a torque up to a predetermined make-up torque.

As is shown in Fig. 3, the pipe coupling unit 11 and the clamp 9 are gradually lowered while the drill pipe section 1 is transferred to a position in line with the drill string 2. Then, the mud flow towards the mud head 16 connected to the drill string 2 is interrupted by closing the valve 19. This is represented in Fig. 3 by the outlined

portion of an initially dark portion of the conduit 17. Immediately after the mud flow to the mud head 16 is interrupted, the mud head 16 is disconnected from the drill string by means of the pipe coupling unit 11.

When the feeding of mud to the drill string 2 is interrupted, mud which has been stored in the mud buffer storage space 66 is expelled therefrom by the expulsion structure 67. Furthermore, the interruption of the feeding of mud to the drill string 2 entails a pressure drop at the proximal end of the drill string 2. In response to this pressure drop, the valves 70 and a valve 82 operated by a spring 83 in the mud buffer storage device 60 are closed to prevent mud in the drill string 2 from flowing back to the proximal end of the drill string 2. Thus, the supply of mud to a mud motor 71 at or near a distal end of the drill string 2 for driving a drill bit 72 is continued after the feeding of mud to the drill string is interrupted. Thus, the rate of progress of the drilling process is substantially increased, not only by the time which is gained by increasing the net drilling time, but also because the normal operating equilibrium of the drilling system is disturbed much less, so that the maximum rate of progress can be maintained for a larger proportion of the total drilling time.

It is observed that in principle, a single one-way valve in any position in the drill string could be used. However, providing a one-way valve 82 on the mud buffer storage device 60 provides the advantage that the device can be used immediately and that any expansion of the fluid in the mud buffer storage device 60 contributes to the mud supply at the distal end of the drill string. The valves 70 which are provided in the drill string 2 between its proximal end and the mud buffer storage device 60 ensure that during each coupling operation expansion of fluid in the drill string 2 between the mud buffer storage device 60 and the proximal end of the drill string contributes to the mud supply at the distal end of the drill string 2 as well, and

substantially prevents backflow of mud at the proximal end of the drill string.

In the meantime, as shown in Fig. 4, the drill pipe section 1 has reached a position in line with the drill string 2, but still remote thereof. The mud head 16 is being removed from between the drill pipe section 1 and the drill string 2, so that the drill pipe section 1 can be connected to the drill string 2.

In the meantime, the drill pipe section 1 to be coupled to the drill string 2 has been accelerated by the drive 40 to substantially the same rotational velocity as the rotational velocity of the drill string 2, and the drill pipe section 1 is lowered until its lower coupling end is introduced into the drill pipe section clasping structure 12 (Fig. 5). When the drill pipe section 1 has reached its desired level, the drill pipe section clasping structure 12 is operated to engage the drill pipe section 1 and the drill pipe section engagement structure 35 of the pipe handler is released from the drill pipe section 1. Subsequently, the pipe coupling unit rotates the drill pipe section 1 relative to the drill string 2 to make the connection between these parts 1, 2.

After the connection has been made, the rotating spider clamp 9 is brought into engagement with the drill string 2 and takes over the function of driving and carrying the drill string 2 from the pipe coupling unit 11, and the mud flow through the mud head is started immediately. Because it is not necessary to move the removed mud head to the free end of the connected drill string and to connect that mud head before the mud flow can be restarted, the downtime of the mud flow at each connection can be reduced substantially. In particular if the drill string is rotated continuously, the reduced downtime of the mud flow while an additional drill pipe section is being connected thereto, substantially reduces wear and disturbances of mechanical and hydrodynamic equilibrium in the bore hole.

As appears from Fig. 9, a buffer quantity of mud is stored in a distal portion of said drill string 2 and, more

specifically, closely adjacent the distal end of said drill string. The closer the buffer quantity of mud is stored to the distal end of the drill string 2, the earlier the mud storage facility in the drill string is made available after the start of the drilling of a bore hole. Closeness of the buffer storage space 66 to the distal end of the drill string 2 is also advantageous, because pressure losses between the buffer storage and the distal end of the drill string 2 during the interruption of the feeding of mud to the drill string 2 are reduced.

Subsequently, as is shown in Fig. 6, the pipe handler 34 is moved away from the drill string 2 in a direction radial to the string 2. The pipe coupling unit 11 is moved upward along the added drill pipe section 1.

As the pipe coupling unit 11 and the pipe handler 34 move upward, the uppermost drill pipe section of the drill string is guided by the mud head 15 attached to the newly connected drill pipe section 1, which mud head 15 is, in turn, guided by the vertical portion 37 of the circulating guide track 36 for guiding the mud heads 15, 16.

It is observed that in the present example the drill string is oriented vertically, but that the drill string can also be oriented in a slanting or even horizontal orientation.

In practice, if a mud pump 14 is stopped, it takes several minutes after a restart until the pump 14 is operating at its optimum level. This problem is avoided by continuous operation of the mud pump 14. Mud fed by the mud pump can for instance be returned to the mud pump via a return conduit.

In the present example, a mud buffer storage 43 is provided downstream of the mud pump 14. Because mud supplied by the mud pump 14 is buffered between the pump 14 and the mud head or mud heads in a time interval between disconnection of one of the mud heads 15, 16 from the string 2 and connection of the drill pipe section 1 connected to the other one of the mud heads 16, 15 to the string 2, a volume

of mud is collected which is pressed through the conduit immediately after the connection between the conduit 17 and the string is re-established. Thus, a quicker build-up of mud circulation is obtained after interruption of the mud circulation.

The mud buffer storage 43 is provided with a mud storage chamber 44 and a chamber 45 filled with nitrogen or another suitable propellant. The chambers are separated by a membrane 46. While the mud supply structure is disconnected from the string 2, the mud storage chamber 44 expands and is filled with mud against the pressure of the propellant in the chamber 45. As soon as the connection between the conduit 17 and the string 2 is re-established, the gas presses the stored mud out of the chamber buffer 43, so that the output of the mud circulation structure is temporarily boosted.

In the chambers 43, 44, support baffles 54, 55 with grids of passages are provided to support the membrane 46 in its extreme end conditions.

The conduit 17 has two conduit branches 47, 48, each directing to one of said mud heads 15, 16. This provides a simple and effective connection between the mud heads 15, 16 and the mud pump 14.

The mud circulation structure further includes two mud buffer storages 49, 50 (Figs. 1-6 and 8), each communicating with one of the branches 47, 48 closely upstream of the shut-off valves at the mud heads 15, 16. Like the mud buffer storage 43, these two mud buffer storages 49, 50 each include a mud chamber 51 and a gas-filled chamber 52 separated from the mud chamber 51 by a membrane 53. Baffles 56, 57 are mounted in the chambers 51, 53 to limit deformation of the membrane 52. Instead of a membrane, other movable separations like a piston can be provided as well.

In operation, mud is alternately fed via one and the other of the mud heads 15, 16. In a first operating condition, mud is fed towards and buffered near said first mud head 15 while mud is being fed via the other mud head 16. In a second, alternative operating condition, mud is fed

towards and buffered near the other mud head 16 while mud is being fed via the first mud head 15. The main purpose of these buffer storages 49, 50 is to dampen shut-off and release shocks in the mud circulation structure when the valves 19 in the mud heads 15, 16 are opened or closed. Buffering in buffer storages communicating with the branches 47, 48 furthermore provides the advantage that a quick boosting effect is achieved, because little pressure is lost between the buffer and the mud head and little mud has to be accelerated after the valve 19 has been opened to restart the mud flow through the respective mud head 15, 16.

It will be readily apparent to the skilled person that, although the above examples relate to the drilling and lining of oil and gas wells, accordingly adapted modes of carrying out the present invention can also be used in connection with other ground drilling operations.

CLAIMS

1. A method for drilling a bore hole in the lithosphere, including:

the feeding of mud to a drill string (2) via a mud circulation structure;

canalizing mud through the drill string (2) to a distal end of the drill string (2); and

each time the drill string (2) has progressed into the lithosphere over a predetermined distance, disconnecting the drill string (2) from the mud circulation structure so that the feeding of mud to the drill string (2) is interrupted, connecting a drill pipe section (1) to the mud circulation structure and connecting the drill pipe section (1) to the drill string (2);

wherein a buffer quantity of mud is stored in the drill string (2) during the feeding of mud to the drill string and wherein at least a portion of said buffer quantity of mud is fed in the direction of the distal end of the drill string (2) during said interruption of the feeding of mud to the drill string (2).

2. A method according to claim 1, wherein said buffer quantity of mud is stored in a chamber (66) while loading a resilient structure (73, 74) and wherein the directing of at least a portion of said stored buffer quantity of mud to the distal end of the drill string is accomplished by relaxation of said resilient structure (73, 74).

3. A method according to claim 2, wherein during storage of said buffer quantity of mud, a propellant of said resilient structure (73, 74) is compressed and wherein said propellant expands during the direction of at least a portion of said stored buffer quantity of mud to the distal end of the drill string (2).

4. A method according to any one of the preceding claims, wherein said buffer quantity of mud is stored in a distal portion of said drill string (2).

5. A method according to any one of the preceding claims, wherein said buffer quantity of mud is stored closely adjacent the distal end of said drill string (2).

6. A method according to any one of the preceding claims, wherein in response to a pressure drop at the proximal end of the drill string, a valve (70, 82) is closed to prevent mud in the drill string (2) from flowing back to the proximal end of the drill string (2).

7. A method according to any one of the preceding claims, wherein each time the drill string (2) has progressed into the lithosphere over a predetermined distance, a connecting cycle is started, said connecting cycle including the steps of:

connecting one mud head (15, 16) of the mud circulation structure to the drill pipe section (1) to be connected;

disconnecting another mud head (16, 15) of the mud circulation structure from the drill string (2); and

subsequently connecting said drill pipe section (1) connected to said mud head (15, 16) to the drill string (2);

a next connection cycle including the step of connecting said other mud head (16, 15) to a next drill pipe section (1) to be connected to the drill string (2).

8. A method according to claim 7, wherein a mud pump (14) of the mud circulation structure is continuously active.

9. A method according to claim 8, wherein mud supplied by said mud pump (14) is buffered between said pump (14) and at least one of said mud heads (15, 16) in a time interval between disconnection of one of said mud heads (15, 16) from the drill string (2) and connection of said drill pipe section (1) connected to the other one of said mud heads (16, 15) to the drill string (2).

10. A method according to claim 9, wherein mud is alternately fed via one and the other of said mud heads (15, 16), and wherein, in a first operating condition, mud is fed towards and buffered near said one mud head (15, 16) while mud is being fed via said other mud head (16, 15) and wherein, in a second, alternative operating condition, mud is

fed towards and buffered near said other mud head (16, 15) while mud is being fed via said one mud head (15, 16).

11. A method according to any one of the preceding claims, wherein said drill string (2) is continuously rotated.

12. A storage device for storing mud in a drill string during lithosphere drilling, said device (60) including:

a first connection structure (61) for connection to a drill pipe section or to an identical device (60), said first connection structure (61) including a first passage (62) to allow the passage of mud;

a second connection structure (63) opposite said first connection structure (61), for connection to a drill pipe section, to a mud motor or to a first connection structure (61) of an identical device (60), said second connection structure (63) including a second passage (64) to allow the passage of mud;

a mud flow channel (65) interconnecting said first and second passages (61, 63);

a buffer storage space (66) communicating with the mud flow channel (65) for storing a buffer quantity of mud; and

an expulsion structure (67) for expelling at least a portion of a buffer quantity of mud from said storage space (66).

13. A device according to claim 12, wherein the expulsion structure (67) is a passive resilient structure for increasing the volume of the buffer storage space (66) in response to a pressure rise in the buffer storage space (66) and for reducing the volume of the buffer storage space (66) in response to a pressure drop in the buffer storage space (66).

14. A device according to claim 12 or 13, wherein the expulsion structure (67) is a resilient structure compressible by increasing the pressure in the buffer storage space (66) and expandable by reducing the pressure in the buffer storage space (66).

15. A device according to claim 14, wherein said expulsion structure (67) includes a chamber (73) containing a propellant and bounded from a mud buffer storage chamber by a displaceable boundary (74).

16. A device according to claim 15, wherein said boundary is formed by a piston (74).

17. A device according to any one of claims 12-16, wherein said buffer storage space is contained in a ring-shaped chamber (66) co-axial with said channel (65).

18. A device according to claim 17, wherein said piston (74) is ring-shaped.

19. A device according to any one of claims 12-18, further including a one-way valve (82) upstream of said buffer storage space (66).

20. A drill string including a device (60) according to any one of claims 12-19, further including a one-way valve (70, 82) upstream of said buffer storage space (66).

21. A lithosphere drilling assembly including a drill string (2) including a device (60) according to any one of claims 12-19 and a mud circulation structure for circulating mud through the drill string (2), including:

a mud pump (14);

at least two mud heads (15, 16);

at least one conduit (17) for directing mud from the mud pump (14) to and through each of said mud heads (15, 16); and

means for shutting off said mud flow conduit (17) for alternately directing the mud flow through each one of said mud heads (15, 16).

22. A drilling assembly according to claim 21, wherein said mud circulation structure further includes at least one mud buffer storage (43, 49, 50) downstream of said mud pump (14).

23. A drilling assembly according to claim 21 or 22, in which said at least one mud buffer storage (43, 49, 50) of said mud circulation structure includes a mud chamber (44, 51) and a resilient structure (45, 46, 52, 52) for exerting a

resilient return pressure counteracting expansion of the mud chamber (44, 51).

24. A drilling assembly according to any one of claims 21-23, wherein said mud circulation structure further includes at least two conduit branches (47, 48), each directing to one of said mud heads (15, 16).

25. A drilling assembly according to claim 24, wherein said mud circulation structure further includes at least two mud buffer storages (49, 50), each communicating with one of said branches.

26. A drilling rig for lithosphere drilling including a drilling assembly according to any one of claims 21-25, means for moving a drill string (2) along a drill string axis and a mud head guide structure (36) for guiding each of said mud heads (15, 16) along a path including a section (37) co-axial with said drill string axis.

27. A drilling rig for lithosphere drilling including a drilling assembly according to any one of claims 21-25 and a drill string drive unit for driving rotation of the drill string (2), said drill string drive unit (11) comprising:

a drill string engagement structure (13) for circumferentially engaging the drill string (2); and

a drill string drive including a drive motor operatively coupled to said drill string engagement structure (13) for driving rotation of said drill string engagement structure (13),

said drill string drive unit (11) having a continuous passage for receiving a portion of said drill string (2).

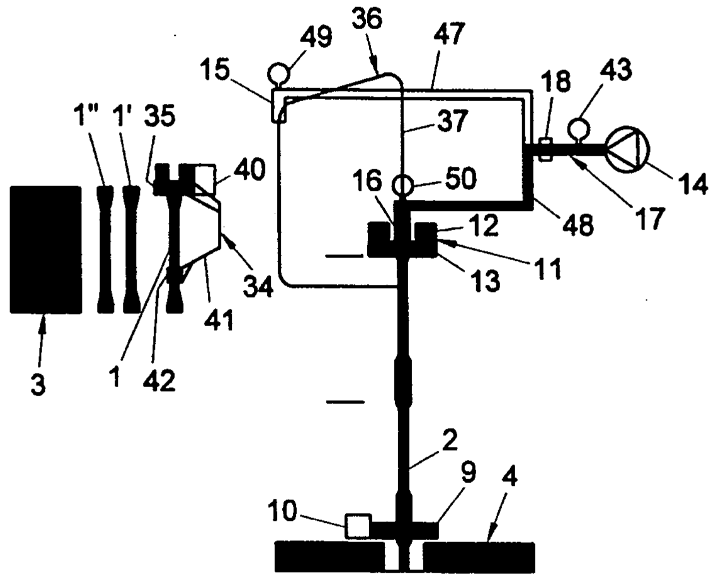

49
36
47
15
18
43
1"
1'
35
37
40
16
50
14
48
17
12
11
34
13
41
3
1
42
2
9
4
10

Fig. 1

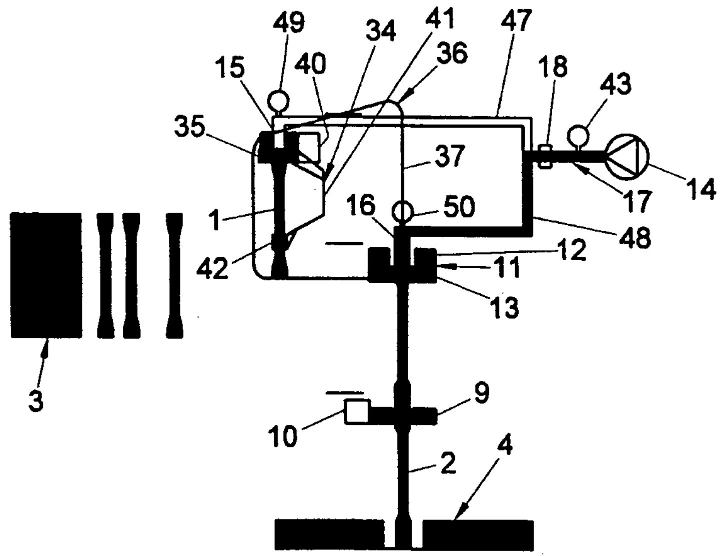

49
34
41
47
36
15
40
18
43
35
37
17
14
1
16
50
48
12
42
11
13
3
9
10
4
2

Fig. 2

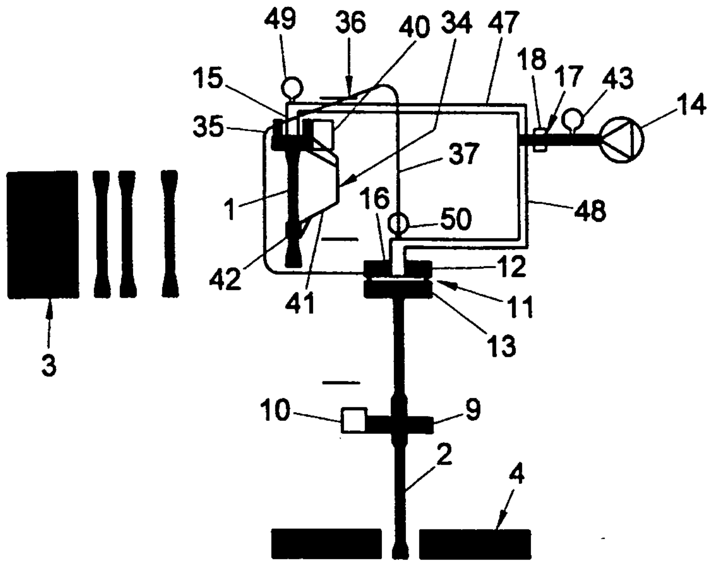

49
36
40
34
47
18
17
43
14
15
35
37
1
16
50
48
42
41
12
11
13
3
10
9
2
4

Fig. 3

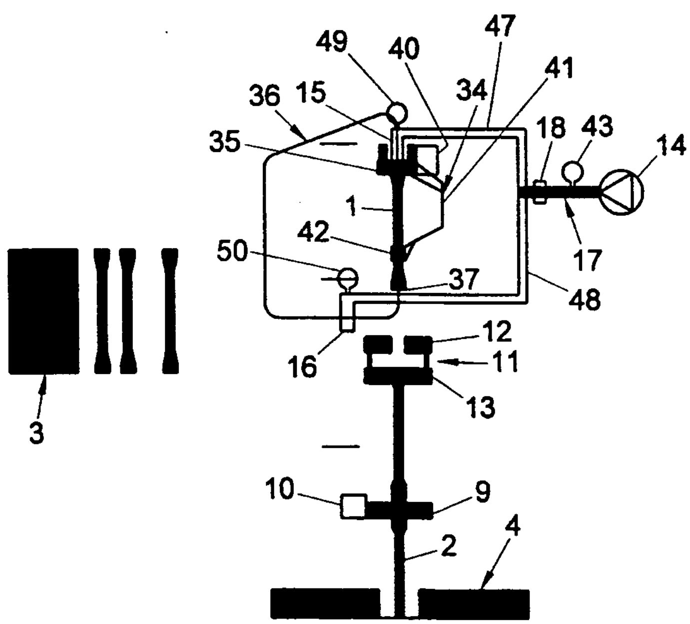

47
49
40
41
36
15
34
18
43
14
35
1
42
17
50
37
48
12
11
16
13
3
10
9
2
4

Fig. 4

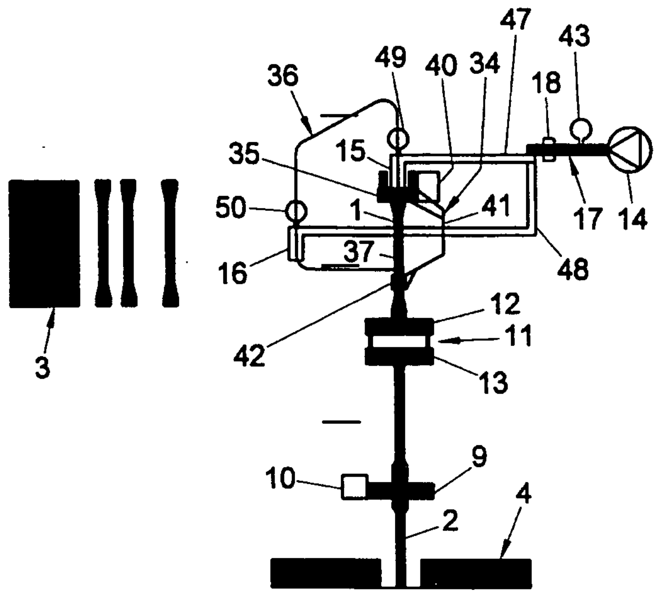

47
43
49
40
34
36
18
35
15
50
1
41
17
14
37
16
48
12
11
42
3
13
10
9
4
2

Fig. 5

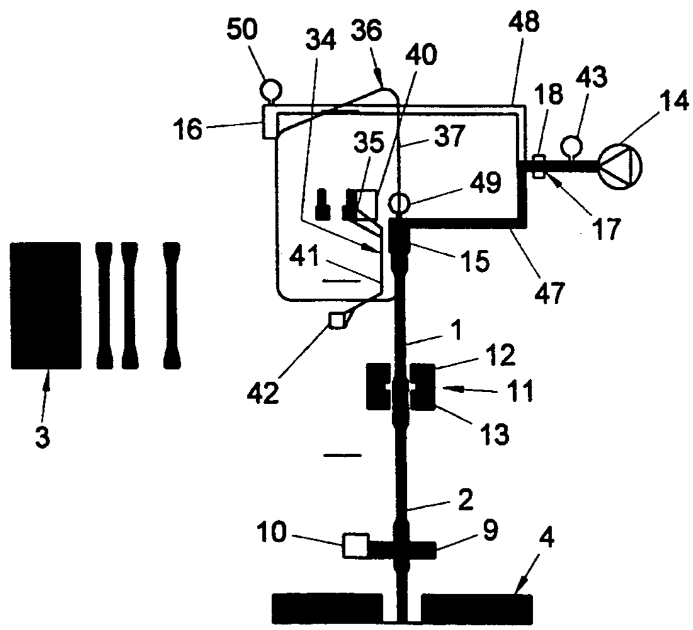
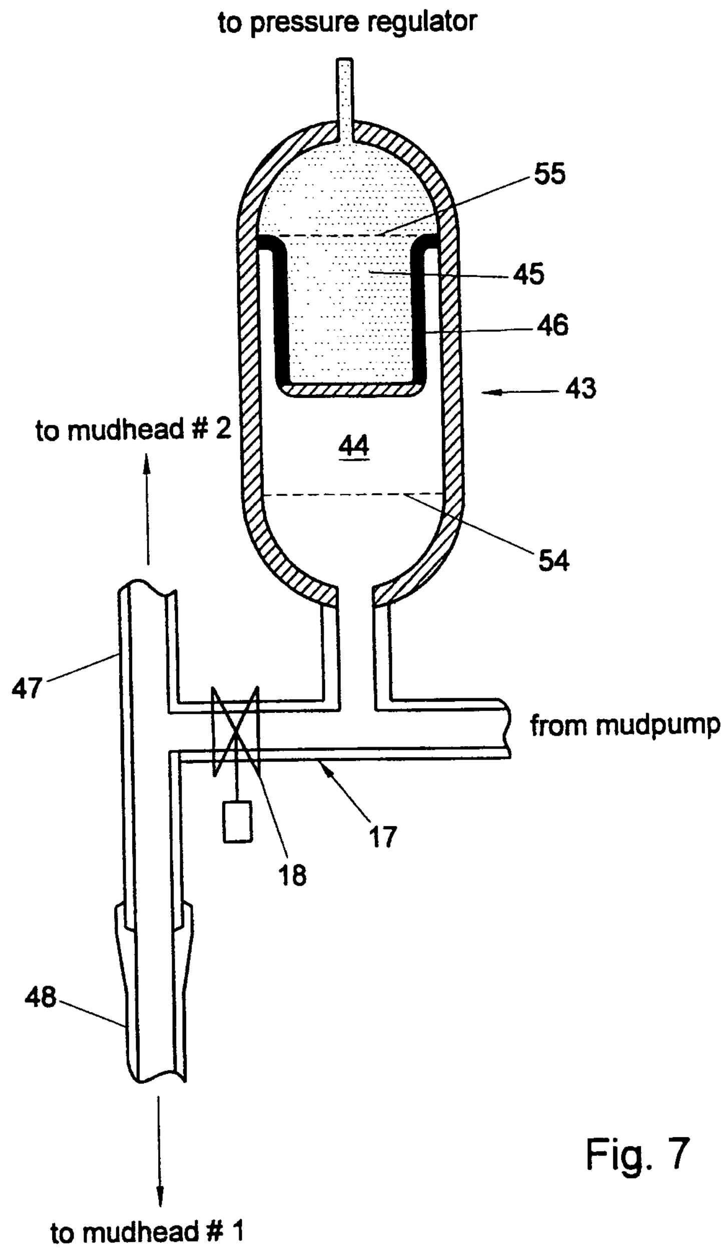

50
34
36
48
40
43
18
14
16
35
37
49
17
41
15
47
1
42
12
11
3
13
2
10
9
4

Fig. 6



to pressure regulator
55
45
46
43
44
54
to mudhead # 2
47
from mudpump
17
18
48
to mudhead # 1

Fig. 7

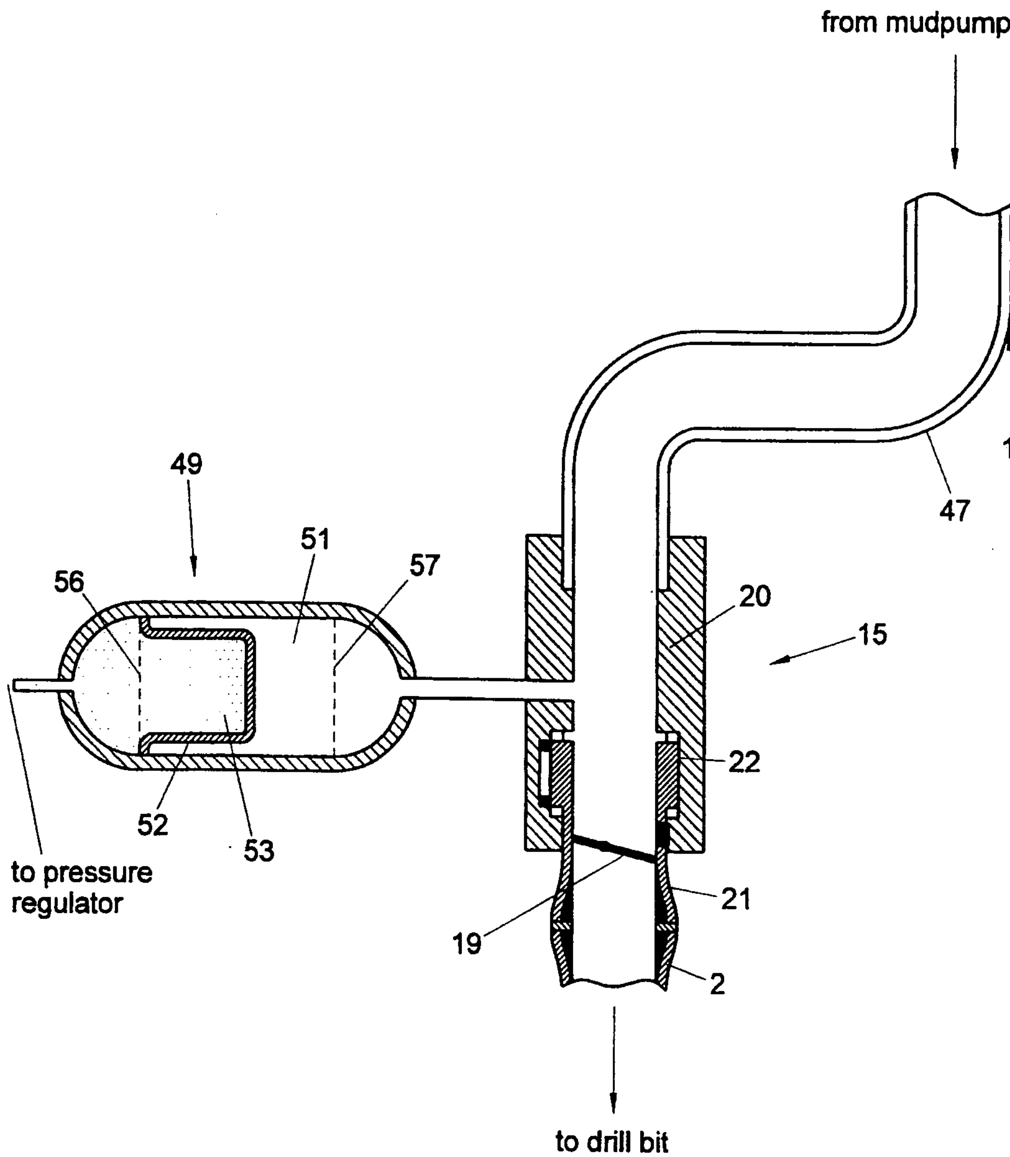

from mudpump
17
47
49
51
56
57
20
15
22
52
53
to pressure regulator
21
19
2
to drill bit

Fig. 8

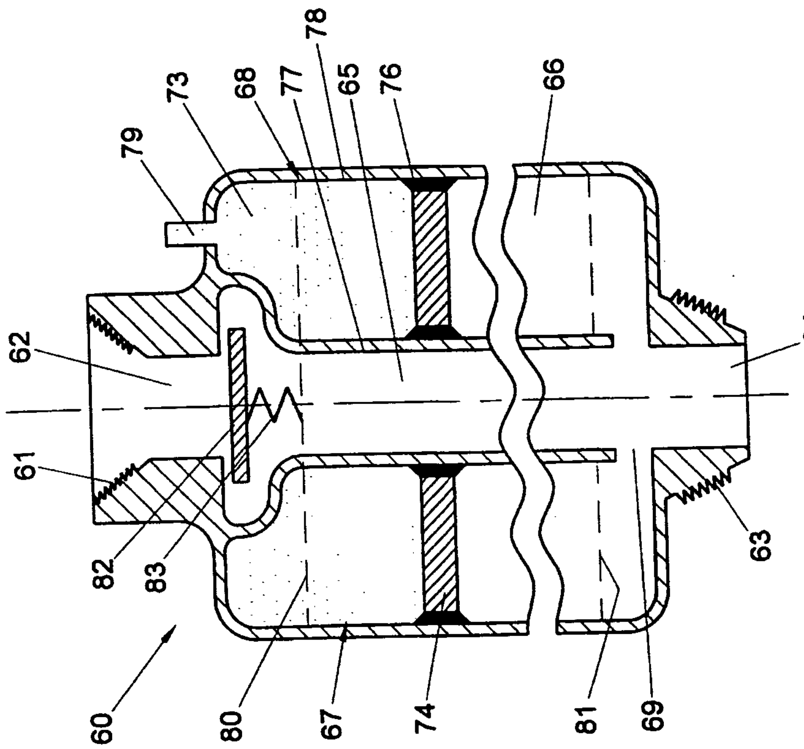

60
80
67
74
81
69
61
82
83
62
63
64
79
73
68
77
78
65
76
66

Fig. 10

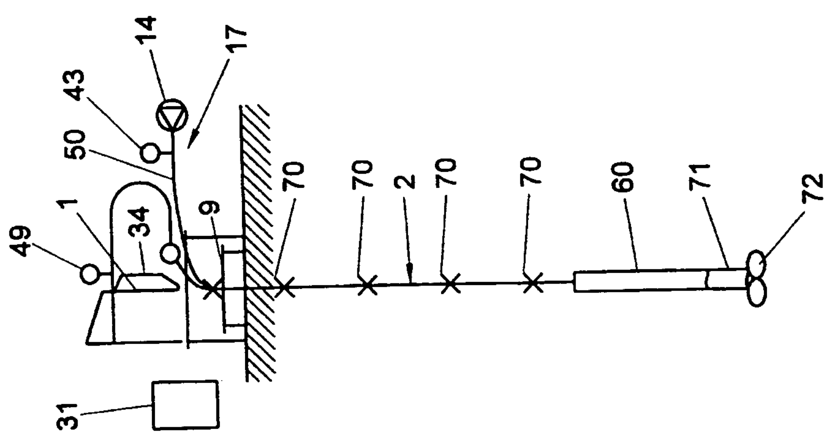

31
49
1
34
9
50
43
14
17
70
70
2
70
70
60
71
72

Fig. 9

INTERNATIONAL SEARCH REPORT

Int. ional Application No
PCT/NL 97/00725

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 E21B21/00 E21B21/08

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 E21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 3 766 992 A (TIRASPOLSKY ET AL.) 23 October 1973 see column 2, line 15-37; claim 1	1,2,4,5, 12-14
Y		21,24,27
A		3,15-18

Y	US 3 559 739 A (HUTCHISON STANLEY O) 2 February 1971 see column 1, line 14 - line 21; claim 1; figure 2	21,24,27
A		7,8

A	EP 0 289 673 A (PANGAEA ENTERPRISES INC) 9 November 1988 see column 21, line 46-55; figure 20	3,7,8

A	US 4 315 553 A (STALLINGS JIMMIE L) 16 February 1982	

	-/--	

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
14 August 1998	07/09/1998
Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Authorized officer Bellingacci, F

2

INTERNATIONAL SEARCH REPORT

In: tional Application No
PCT/NL 97/00725

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0 736 664 A (KLAUS OBERMANN GMBH) 9 October 1996 -----	

2

Form PCT/ISA/210 (continuation of second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/NL 97/00725

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 3766992 A	23-10-1973	FR 2045255 A	26-02-1971
		DE 2030280 A	07-01-1971
		GB 1272210 A	26-04-1972
		NL 7008478 A	29-12-1970
		SE 359884 B	10-09-1973
US 3559739 A	02-02-1971	CA 935149 A	09-10-1973
		DE 2030169 A	07-01-1971
		DK 131739 B	25-08-1975
		FR 2046938 A	12-03-1971
		GB 1312841 A	11-04-1973
		NL 7009046 A,B	22-12-1970
EP 0289673 A	09-11-1988	CA 1319361 A	22-06-1993
		US 4683944 A	04-08-1987
		AU 591558 B	07-12-1989
		AU 7260087 A	10-11-1988
		CA 1335811 A	06-06-1995
		US 4799544 A	24-01-1989
		US 4836305 A	06-06-1989
		US 4924949 A	15-05-1990
US 4315553 A	16-02-1982	NONE	
EP 0736664 A	09-10-1996	DE 19512076 A	10-10-1996